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HABITAT SUITABILITY INDEX MODELS: FOX SQUIRREL

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PREFACE

This document is part of the Habitat Suitability Index (HSI) Model Series (FWS/OBS-82/10), which provides habitat information useful for impact assessment and habitat management. Several types of habitat information are provided. The Habitat Use Information Section is largely constrained to those data that can be used to derive quantitative relationships between key environmental variables and habitat suitability. The habitat use information provides the foundation for HSI models that follow. In addition, this same information may be useful in the development of other models more appropriate to specific assessment or evaluation needs.

The HSI Model Section documents a habitat model and information pertinent to its application. The model synthesizes the habitat use information into a framework appropriate for field application and is scaled to produce an index value between 0.0 (unsuitable habitat) and 1.0 (optimum habitat). The application information includes descriptions of the geographic ranges and seasonal application of the model, its current verification status, and a listing of model variables with recommended measurement techniques for each variable.

In essence, the model presented herein is a hypothesis of species-habitat relationships and not a statement of proven cause and effect relationships. Results of model performance tests, when available, are referenced. However, models that have demonstrated reliability in specific situations may prove unreliable in others. For this reason, feedback is encouraged from users of this model concerning improvements and other suggestions that may increase the utility and effectiveness of this habitat-based approach to fish and wildlife planning. Please send suggestions to:

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FOX SQUIRREL (Sciurus niger)

HABITAT USE INFORMATION

General

The fox squirrel (Sciurus niger) is the largest of the North American tree squirrels. The species is widely distributed throughout eastern North American and has been introduced in many portions of the West (Wright 1979). Fox squirrels also have expanded their range westward through utilization of gallery forest habitats along major river drainages (Armstrong 1972; Wright 1979).

Food

Foods consumed by the fox squirrel include mast, tree buds, insects, tubers, bulbs, roots, bird eggs, and the seeds of spring fruiting trees (Lowery 1974). Winter foods are chiefly mast produced by oaks (Quercus spp.), hickories (Carya spp.), American beech (Fagus grandifolia), magnolias (Magnoliaceae spp.), gums (Hamamelidaceae spp.), and dogwoods (Cornus spp.). Agricultural crops such as corn, soybeans, oats, wheat, and fruit crops are also readily eaten by the fox squirrel (Brown and Yeager 1945).

Water

Succulent vegetation normally satisfies the moisture requirements of fox squirrels (Allen 1943; McConnell, pers. comm.). Water may be utilized when present; however, the lack of it is not a limiting habitat factor for the fox squirrel (U.S. Forest Service 1971).

Cover

Although fox squirrels inhabitat a wide variety of forest types, they are most abundant in open forest stands with little understory vegetation (Taylor 1974). Ideal habitat is comprised of small stands of large trees interspersed with agricultural lands. Optimal fox squirrel habitat in Michigan was small units of mature oak-hickory woodland connected by small wooded strips that served as travel lanes for squirrels (Allen 1943). Fox squirrel habitat in Ohio consisted of small, 2 to 121.4 ha (5 to 300 acres) farm woodlots (Baumgartner 1943).

Fox squirrels use leaf nests or tree cavities for shelter and litter rearing (Baumgartner 1943). However, they appear to use leaf nests more often

than do gray squirrels (S. carolinensis) (Bakken 1952 cited by Taylor 1974; Donohoe and Beal 1972). Fox squirrels in Ohio utilized one to three shelters in their territory, at least one of which was a tree cavity (Donohoe and Beal 1972).

Hickories, white oak (Quercus alba), scarlet oak (Q. coccinea), and beech were the most frequently selected trees for construction of leaf nests in West Virginia, Ohio, and Illinois (Sanderson et al. 1980). The presence of grapevines (Vitus spp.) in a tree increased the likelihood of the trees being selected as a leaf nest site. Based on the average number of leaf nests constructed by a fox squirrel per year, it appears that four to six canopy-reaching grapevines per hectare (1.5 to 2.3/acre) provide an adequate number of leaf nest anchorages. Trees containing summer and winter leaf nests in Ohio averaged 37.8 cm (15.1 inches) dbh and 32.8 cm (13.1 inches) dbh, respectively (Baumgartner 1939).

Sassafras (Sassafras albidum), sugar maple (Acer saccharum), elm (Ulmus spp.), and beech contained a significantly greater proportion of suitable cavities than expected on the basis of their abundance in Illinois (Nixon et al. 1980). In contrast, walnut (Juglans spp.) and white oak contained significantly fewer cavities than expected. Den trees in Ohio had an average dbh of 53 cm (21.2 inches) and were an average of 50.9 m (58.6 yd) from the nearest woodland border (Baumgartner 1939). Eighty-eight percent of the den trees in eastern Texas had an average dbh of 30 cm (12 inches) or more (Baker 1944).

Reproduction

The reproductive requirements of the fox squirrel are assumed to be identical with cover requirements, as described above.

Interspersion

The home range of the fox squirrel in the Southeast is normally from 2 to 4 ha (5 to 10 acres) (U.S. Forest Service 1971). The mean home range size for male and female fox squirrels in Nebraska was 7.56 ha (18.7 acres) and 3.55 ha (8.8 acres), respectively (Adams 1976). A positive relationship exists between fox squirrel home range size and the area of the inhabited woodlot or forest stand (Adams 1976; Nixon pers. comm.). Adult female fox squirrels are more sedentary than are adult males or subadults (Nixon et al. 1980). Therefore, adult females are more susceptible to habitat changes that affect the availability of denning sites and food.

Special Considerations

Fox and gray squirrel ranges overlap throughout most of the eastern United States (Bakken 1952 cited by Taylor 1974). Coexistence of the two species is most evident in the western and northern portions of the ranges of both species (Bakken 1952 cited by Taylor 1974). Although the two species may inhabit the same general area, they tend to concentrate in slightly different habitats. Fox squirrels prefer open woodland habitats; gray squirrels typically inhabit large dense stands of hardwoods with dense understory cover

(Taylor 1974). Gray squirrels in Texas were more common in poorly drained lowland areas, whereas fox squirrels were more frequently associated with upland and well drained bottomland habitats (Goodrum 1938). Differences in habitat preference and foraging behavior are reflected in foods eaten. Fox squirrels in Missouri commonly inhabit open forests, forest edges, woodlots, and fence rows, where oak-hickory mast (52.2% of the annual diet) is supplemented with corn and other foods commonly associated with these habitats (Korschgen 1981). Gray squirrels occupy dense forests with nearly closed canopies and abundant ground cover and rely more heavily on oak-hickory mast (73.3% of annual diet) than do fox squirrels.

HABITAT SUITABILITY INDEX (HSI) MODEL

Model Applicability

Geographic area. This model appears to be most applicable in the ranges of the following subspecies of the fox squirrel: s.n. rufiventer, s.n. vulpinus, s.n. ludovicianus, and s.n. limitis (Barkalow pers. comm.). Subspecies inhabiting the Outer Coastal Plain Forest and Southeastern Mixed Forest Provinces (Bailey 1980) appear to have sufficiently different habitat requirements to justify separate or modified habitat model(s).

Season. This model will produce HSI values for year-round habitat needs of the fox squirrel.

Cover types. This model is intended to evaluate fox squirrel habitat in the following cover types (terminology follows that of U.S. Fish and Wildlife Service 1981): Deciduous Forest (DF); Deciduous Tree Savanna (DTS); and Deciduous Forested Wetland (DFW).

Minimum habitat area. Minimum habitat area is defined as the minimum amount of contiguous habitat that is required before an area will be occupied by a species. This information, as it pertains to the fox squirrel, was not found in the literature. The home range of the fox squirrel has been reported to range from 2 to 8 ha (5 to 20 acres). It is assumed that, if less than 2 ha (5 acres) of potentially suitable habitat is available, the HSI will equal 0.0.

Verification level. This model was reviewed by F.S. Barkalow, North Carolina State University, and C.M. Nixon, Illinois Institute of Natural Resources. Improvements suggested by these reviewers were incorporated into this model.

Model Description

Overview. This HSI model for the fox squirrel considers the quality of life requisites for the species in each cover type. Winter food and Cover/reproduction are the only life requisites considered in this model.

The following sections document the logic and assumptions used to translate habitat information for the fox squirrel into the variables and equations

used in the HSI model. Specifically, these sections cover: (1) identification of variables used in the model; (2) definition and justification of the suitability levels of each variable; and (3) description of the assumed relationships between variables.

Figure 1 illustrates the relationships of habitat variables, life requisites, and cover types for the fox squirrel.

Food component. A wide variety of vegetative and animal materials may be consumed by the fox squirrel during the spring, summer, and fall. Winter foods are comprised almost wholly of hard mast and grain. It is assumed that the availability of winter food will be the most limiting component of the food requirements of the fox squirrel.

The winter food value for the fox squirrel is a function of hard mast production and, to a lesser extent, the availability of grain. Optimum food can be supplied by hard mast; however, grain availability may be extremely important during years of little or no mast production. It is assumed that the potential for optimum mast production will occur where a mix of white and red oaks, hickories, walnuts, and other mast producing trees comprise at least 40% of the total canopy cover of the forest or stand. Mast producing trees should equal or exceed 25.4 cm (10 inches) dbh to provide optimum mast production. As tree canopy closure increases above 60%, mast quality and quantity is reduced due to suppression and shading of tree crowns by adjacent trees. It also is assumed that grain within 200 m (220 yds) of a forest or stand will have optimal value as a supplement to the winter diet of the fox squirrel. Available grain in excess of 200 m (220 yds) will have a lower potential as a supplement. The winter diet of fox squirrels will never be completely limited by the absence of a source of grain. It is assumed that potential mast production is at least three times as important in supplying winter food for the fox squirrel as is the availability of grain.

Cover and Reproductive Component. Fox squirrels inhabitat a variety of forest types. However, they are most abundant in open forest stands with sparse understory vegetation.

Although fox squirrels commonly utilize leaf nests for shelter and litter rearing, the presence of tree cavities will increase the quality of the habitat. It is assumed that the physical structure of a forest stand is an indication of the availability of tree cavities. Forest stands dominated by mature to overmature trees are assumed to provide cavities and a sufficient number of sites for leaf nests to meet the cover requirements of the species. Overstory trees which have an average dbh of 38.1 cm (15 inches) or larger are assumed to provide adequate cover and reproductive habitat. Optimum tree canopy closure is assumed to range from 20 to 60%. A canopy closure of less than 20% will indicate less suitable habitat, as will tree density exceeding 60%. Understory vegetation comprised of shrubs may decrease habitat quality for the fox squirrel. Optimum conditions are assumed to occur when the shrub crown closure is 30% or less. Habitat quality will decrease as the shrub density increases above 30%, regardless of tree canopy closure and overstory size. A shrub density of 100% is assumed to be indicative of habitat with no suitability for fox squirrels.

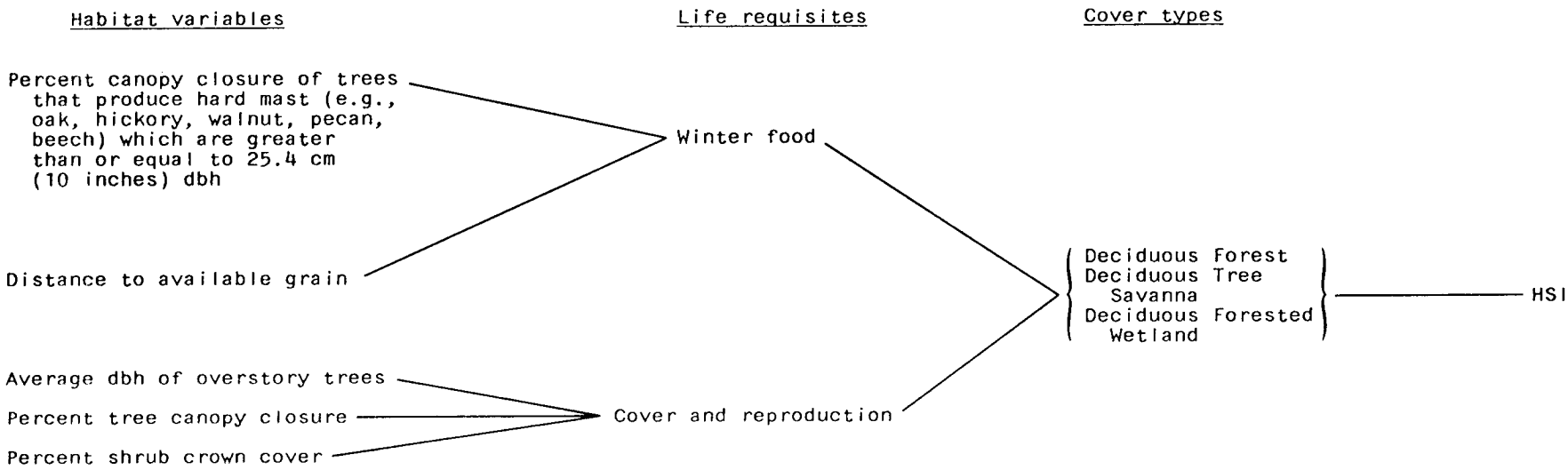
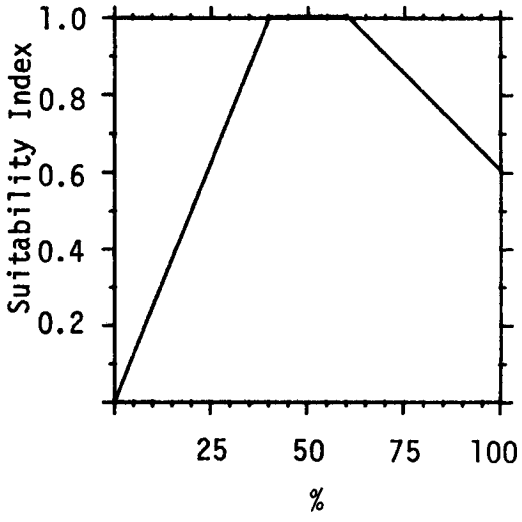


Figure 1. The relationship of habitat variables, life requisites, and cover types to the HSI for the fox squirrel.

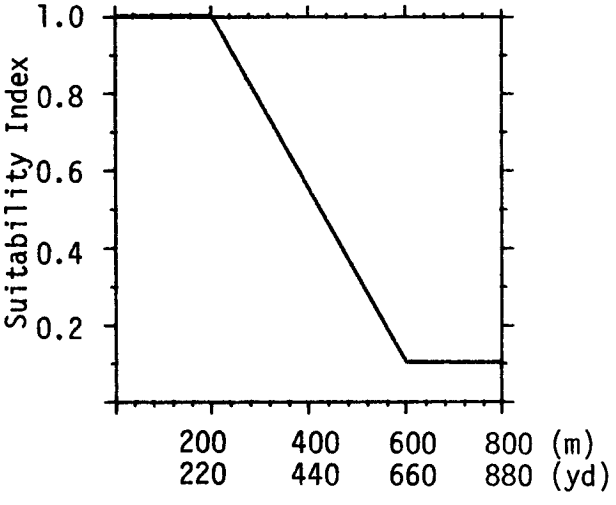
Model Relationships

Suitability Index (SI) curves for habitat variables. This section contains suitability index graphs that illustrate the habitat relationships described in the previous section.

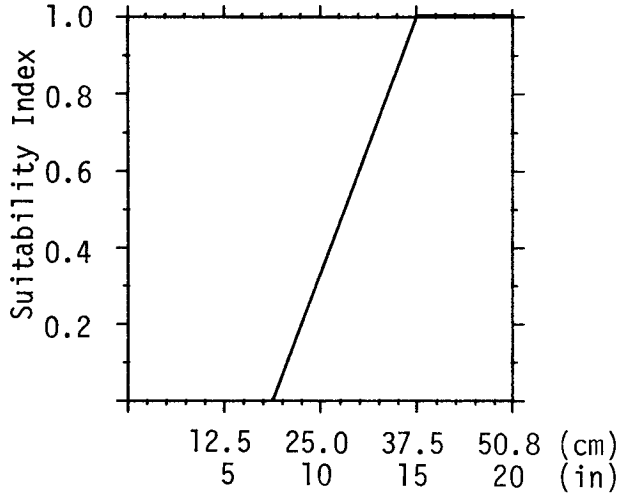
Cover type	Variable	
DF,DTS, DFW	V_1	Percent canopy closure of trees that produce hard mast (e.g., oak, hickory, walnut, pecan, beech) ≥ 25.4 cm (10 inches) dbh.



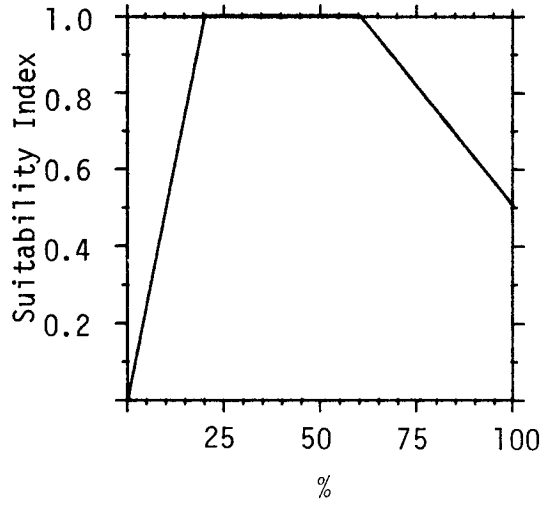
DF,DTS,DFW	V_2	Distance to available grain.



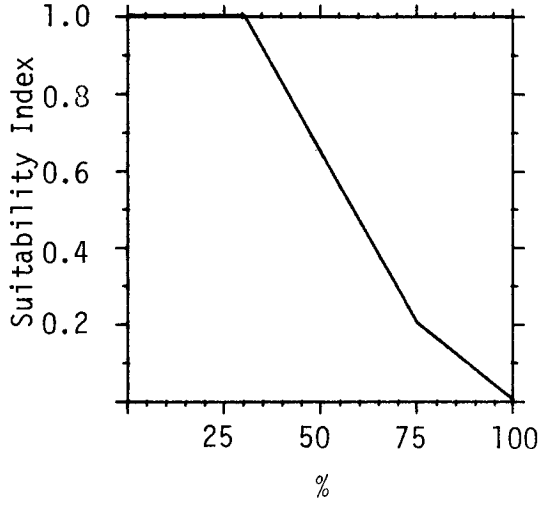
DF,DTS, DFW	V_3	Average dbh of overstory trees.



DF,DTS, DFW	V_4	Percent tree canopy closure.



DF,DTS, DFW	V_5	Percent shrub crown cover.



Equations. In order to obtain life requisite values for the fox squirrel, the SI values for appropriate variables must be combined with the use of equations. A discussion and explanation of the assumed relationships between variables was included under Model Description. The suggested equations for obtaining the food and cover/reproduction values are presented in Figure 2.

Life requisite	Cover type	Equations
Winter food	DF,DTS,DFW	$\frac{3V_1 + V_2}{3}$
Cover/reproduction	DF,DTS,DFW	$(V_3 \times V_4 \times V_5)^{1/3}$

Figure 2. Equations for determining life requisite values by cover type for the fox squirrel.

HSI determination. A HSI value for a single cover type species is based on the limiting factor concept and equals the lowest life requisite value.

Application of the Model

Definitions of variables and suggested field measurement techniques (Hays et al. 1981) are presented in Figure 3.

Variable [definition]		Cover types	Suggested technique
V_1	Percent canopy closure of trees that produce hard mast (e.g., oak, hickory, walnut, pecan, beech) ≥ 25.4 cm (10 inches) dbh [the percent of the ground that is shaded by the vertical projection of the canopies of trees which produce a hard shelled fruit and have a dbh of at least 25.4 cm (10 inches)].	DF,DTS,DFW	Calculated area of plant using crown diameter on strip quadrat

Figure 3. Definitions of variables and suggested measurement techniques.

Variable [definition]		Cover types	Suggested technique
V_2	Distance to available grain [the linear distance from sample point to grain crops that are available to fox squirrels. Grain may be available as standing crop, waste, or stored grain].	DF,DTS,DFW	On site inspection, remote sensing
V_3	Average dbh of overstory trees [the average diameter at breast height (1.4 m/4.5 ft) of those trees which are ≥ 80 percent of the height of the tallest tree in the stand.	DF,DTS,DFW	Cruise for tallest tree in stand. Sample with optical range finder and Biltmore stick on strip quadrat
V_4	Percent tree canopy closure [the percent of the ground surface shaded by a vertical projection of the canopies of all woody vegetation greater than 5.0 m (16.5 ft) tall].	DF,DTS,DFW	Line intercept, remote sensing
V_5	Percent shrub crown cover [the percent of the ground shaded by a vertical projection of the canopies of woody vegetation less than 5 m (16.5 ft) tall].	DF,DTS,DFW	Line intercept

Figure 3. (concluded)

SOURCES OF OTHER MODELS

Numerical habitat models by Flood et al. (1977) and Hallett (1980) were located in the literature.

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16. Abstract (Limit: 200 words)

Habitat preferences and species characteristics of the fox squirrel (Sciurus niger) are described in this publication. It is one of a series of Habitat Suitability Index (HSI) models and was developed through an analysis of available scientific data on the species-habitat requirements of the fox squirrel. Habitat use information is presented in a review of the literature, followed by the development of a HSI model. The model is presented in three formats: graphic, word, and mathematical. Suitability index graphs quantify the species-habitat relationship. These data are then synthesized into a model which is designed to provide information for use in impact assessment and habitat management activities.

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